Preliminary Analysis of GHG Emissions from Cargo Handling Equipment at Ports During Extended Idling

Summary

The California Air Resources Board (ARB) is evaluating opportunities to reduce greenhouse gas emissions (GHG) from cargo handling equipment (CHE) at California ports and intermodal railyards. Carbon dioxide (CO_2) is the largest component of GHG. The highest emitting CHE identified at ports are yard trucks, rubber tired gantry (RTG) cranes, and top and side picks. One method under evaluation is to reduce or eliminate extended idling of this equipment when not lifting or moving containers, or moving about the terminal. While we will be evaluating opportunities to reduce GHG from CHE at both railyards and ports, the data reported herein were collected only at port terminals. Consequently, the possible GHG reductions discussed are related only to port equipment. Data from CHE operating at railyards will be collected in the future.

CHE exhaust temperature data were used to assess extended idling during normal operations at three California ports. The CHE exhaust temperature data were gathered at one Port of Oakland terminal and four terminals at the Ports of Los Angeles and Long Beach. With these terminals' assistance, ARB staff gathered exhaust temperature data from three RTG cranes, six top picks, and two side picks under normal operating conditions over a period extending from one week to 30 days. These exhaust temperature data were originally collected to be used by diesel emission control manufacturers to identify control technologies for this equipment. However, the data proved useful in evaluating idling episodes. The CHE exhaust temperature data were reviewed to identify periods where the exhaust temperature remained at a constant lower temperature indicating periods of extended idling. Idling periods that lasted greater than 10 minutes were considered to be extended idling and these data were compiled and compared to total operating times.

Yard trucks are a significant fraction of the ports cargo handling equipment and similar data will need to be gathered for these vehicles. The exhaust temperature data were available for the non-yard truck cargo handling equipment because the "Regulation for Mobile Cargo Handling Equipment at Ports and Intermodal Rail Yards", which became effective 12/31/06, includes a retrofit compliance option for these equipment types that necessitated exhaust temperature data to be collected for installation of the retrofit. Yard trucks did not have this compliance option, therefore, no exhaust temperatures data has been collected. The equipment inventory for the ports in California includes about 2000 yard trucks, 240 RTG cranes, and over 400 top and side picks. Of the equipment operating at the ports, yard trucks are the most populous.

These data indicate that RTG cranes spend about a third of their operating time idling, while top and side picks idle less than 15 percent of their operating time. Some idling durations were over an hour and a few of the RTG cranes idling episodes were over two hours. If idling times greater than 10 minutes were eliminated, it is estimated that an RTG crane would save approximately 120 gallons of diesel fuel with an associated cost of about $350 and reduce over one metric tonne (MT) of carbon dioxide (CO_2) emissions a year on average. Based on the current statewide RTG crane inventory at California ports, eliminating extended idling of RTG cranes would result in a reduction of about 285 MT of CO_2 emissions and save 29,000 gallons of diesel fuel resulting in a savings of over $83,000 each year.

Top and side picks are typically powered by smaller engines (350-450 horsepower (hp) and 200-300 hp, respectively) than RTG cranes (400-800 hp). The engine sizes plus the estimated percentage of time spent idling for top and side picks result in a lower estimated annual fuel savings and CO_2 emissions while idling. Eliminating extended idling for a typical side pick would save about 110 pounds of CO_2 and 5 gallons of diesel fuel per year. Eliminating extended idling for a typical top pick would save about 270 pounds of CO_2 and 12 gallons of diesel fuel per year. Combined, top and side pick idling is estimated to result in about 53 MT per year of CO_2 statewide and the savings of about 5,300 gallons of diesel fuel based on the top and side pick inventory of California ports. These fuel savings translate into savings of about $16,000 per year.

There may be situations where idling of 10 minutes or more may be appropriate and necessary during normal operation. Further research is needed to determine what constitutes necessary idling and refine the benefits of a reduced idling program. An assessment was made of co-benefits of reduced oxides of nitrogen (NO_X) and diesel particulate matter (PM). It was estimated that if idling over 10 minutes was eliminated for these three equipment types, over two tons of NO_X and 400 lbs of PM would be reduced. If the benefits of reduced idling are not consequential or there are significant detrimental effects, a review of engine performance or emission impacts associated with the increased shutdown or startup should also be made. Spending resources on other emission reduction strategies, like hybrid systems or electrification retrofit systems for RTG cranes, may have greater benefits in reducing fuel consumption and associated emissions.

Data Evaluation Methodology

ARB staff collected exhaust temperature data from CHE at one terminal at the Port of Oakland and four terminals at the Ports of Los Angeles and Long Beach. For periods ranging from about a week to a month, exhaust temperature data were collected from RTG cranes, top picks, and side picks while operating under normal conditions. The exhaust temperature probes were located in the exhaust pipes, usually immediately upstream of the existing muffler. A list of the equipment and brief description are presented in Table 1 below.

Table 1: List of Cargo Handling Equipment Data Logged

Equipment	Manufacturer	Engine	Engine Year	Engine Hours	Data Logging # Days	Data Logging Dates
RTG 1	NA	Caterpillar 3456	2002	8806	16	May 2006
RTG 2	NA	Duetz V8	2005	2095	16	May 2006
RTG 3	Coast Engineering & Mfg. Co.	Cummins KTA19G1	Jan-89	NA	30	June & July 2005
Top Pick 1	Kalmar	Cummins QSM11	2002	4878	16	May 2006
Top Pick 2	Kalmar	Cummins QSM11	2005	1145	16	May 2006
Top Pick 3	Taylor	Cummins M11-C	1998	5463	8	May 2006
Top Pick 4	Fantuzzi	Cummins QSM11	2004	3534	16	May 2006
Top Pick 5	Fantuzzi	Cummins QSM11-C	2004	4505	16	May 2006
Top Pick 6	Mi-Jack or Fantuzzi, MJ50065	Cummins QSM11-C	2001	NA	20	June & July 2005
Side Pick 1	Taylor	Cummins B5.9-C	1998	8435	16	May 2006
Side Pick 2	Taylor	Cummins 6BT5.9-C	Mid - 80's	NA	30	June & July 2005

The data loggers recorded temperatures whether the engine was running or not. When the exhaust temperature data showed steady lower exhaust temperatures (well above ambient temperature) it was assumed that the engine was idling. When the temperatures dropped below this temperature, it was assumed that the engine was turned off.

This data logging can be used to determine the amount of time spent in extended idle. For the purpose of this analysis, an idle time of 10 minutes or more is considered an extended idle. In Figure 1 and Figure 2 below, the morning and afternoon RTG crane exhaust temperatures are displayed. The thick line on the figures represents the exhaust temperature of the RTG crane. An exhaust temperature of about 250 ℃ indicates idling. The extended idling times are noted by the thin line on the figures. Measured exhaust temperatures below the idling exhaust temperature of 250 ℃ indicate when the engine is turned off. The other pieces of equipment identified in Table 1 above had slightly different idle exhaust temperatures, but the idle identification methodology used was basically the same. By identifying the amount of time spent in extended idle, engine off, engine running, and number of days data were collected, the percent of time in extended idle was calculated along with estimates of annual idling time.

Figure 1: RTG Crane Morning Exhaust Temperature and Idle

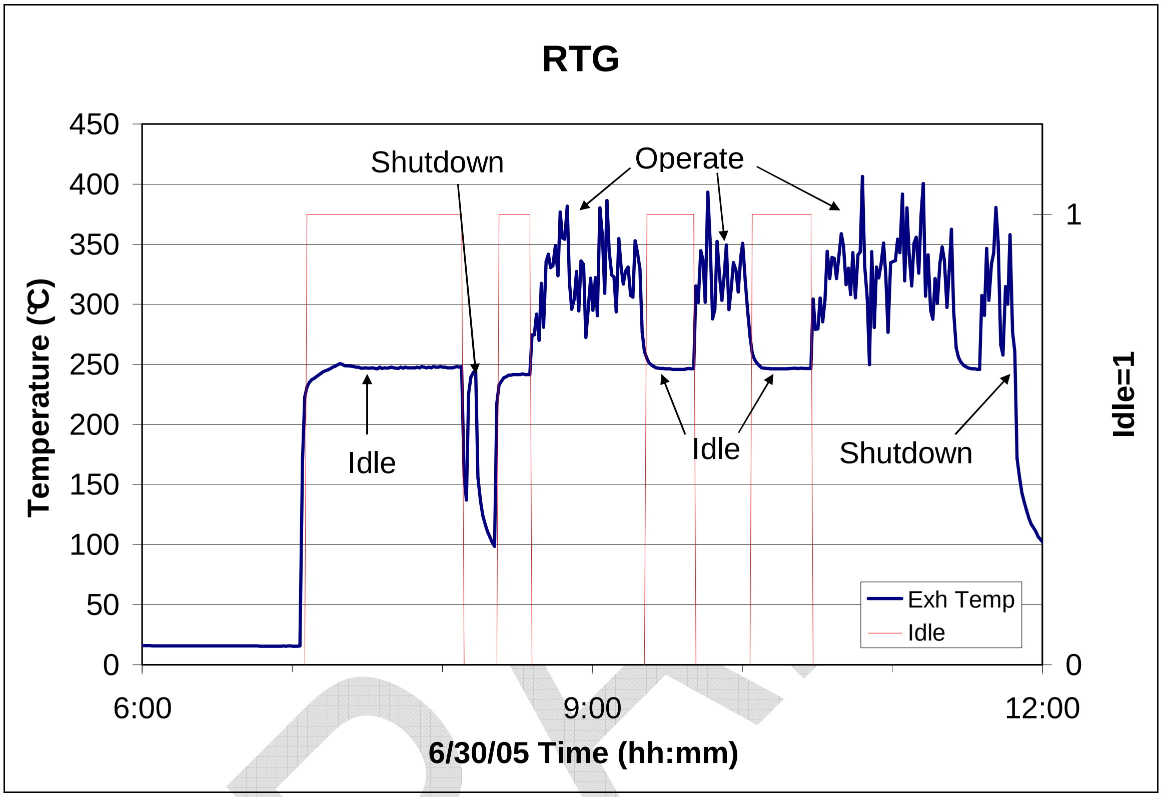
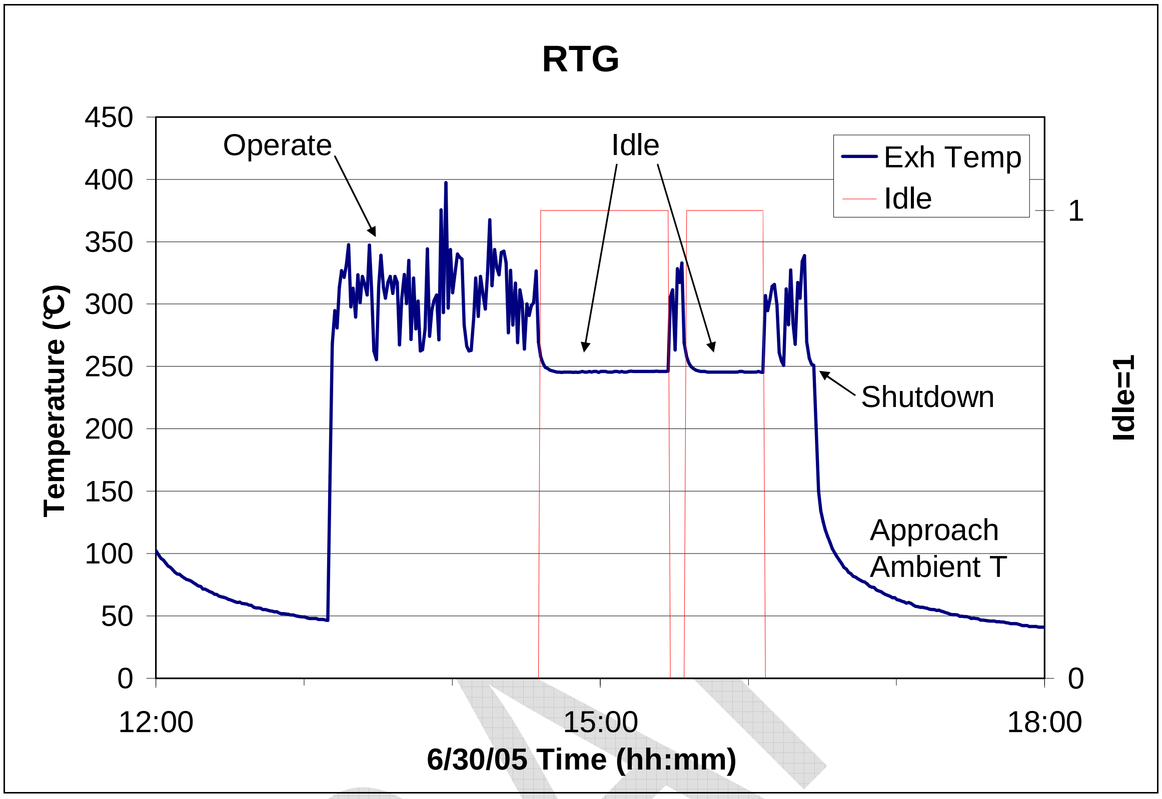


Figure 2: RTG Crane Afternoon Exhaust Temperature and Idle



Results

The individual extended idle times identified from the exhaust temperature data logging were grouped into ranges of idle times for each piece of equipment. The number of occurrences for each idle time range is graphed below in Figure 3 for RTG cranes, Figure 4 for top picks, and Figure 5 for side picks. Some of these extended idles were as long as two hours with one idle time over four hours.

Figure 3: RTG Cranes Extended Idle Times

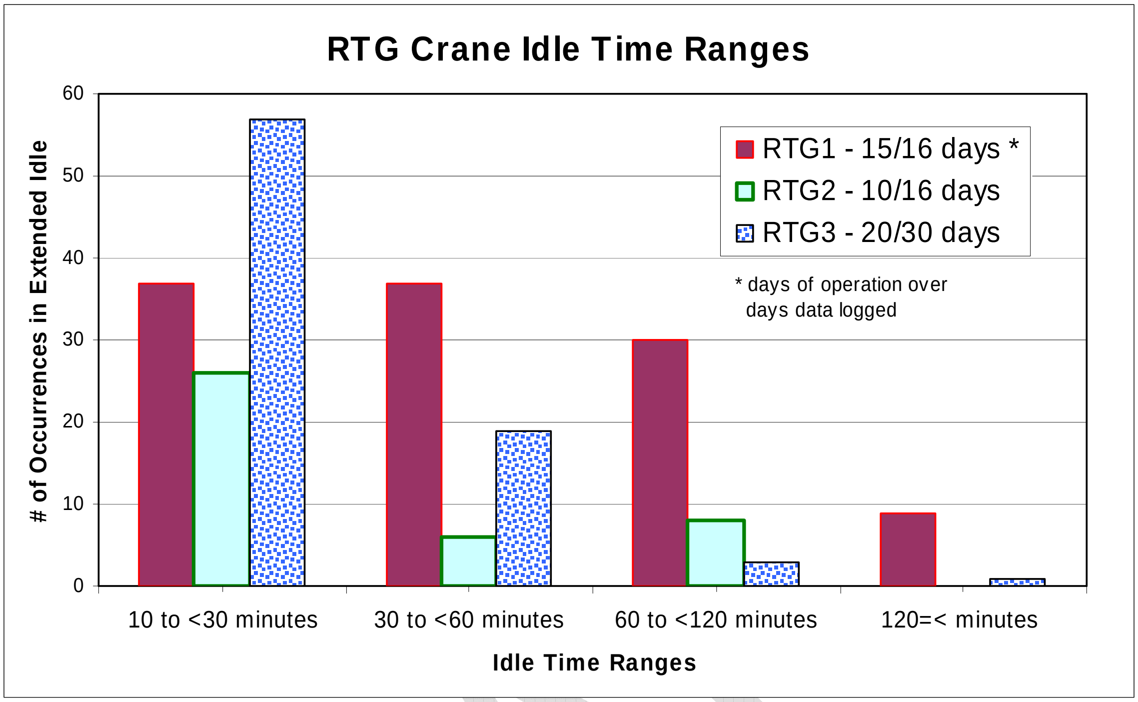


Figure 4: Top Picks Extended Idle Times

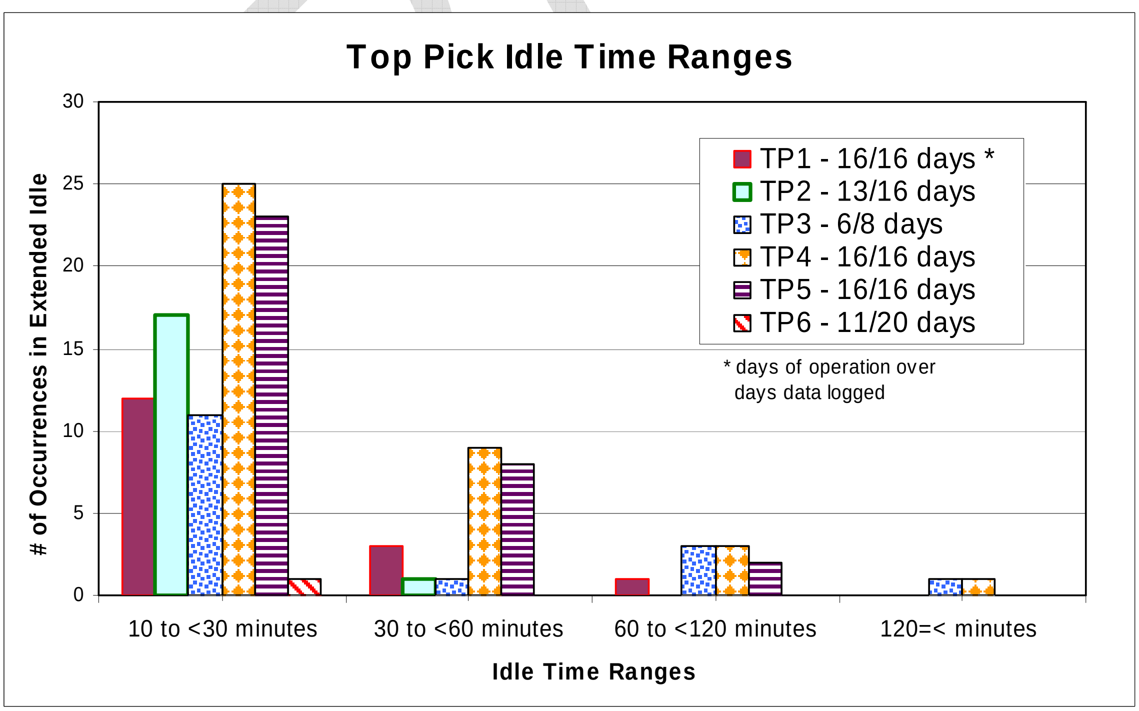
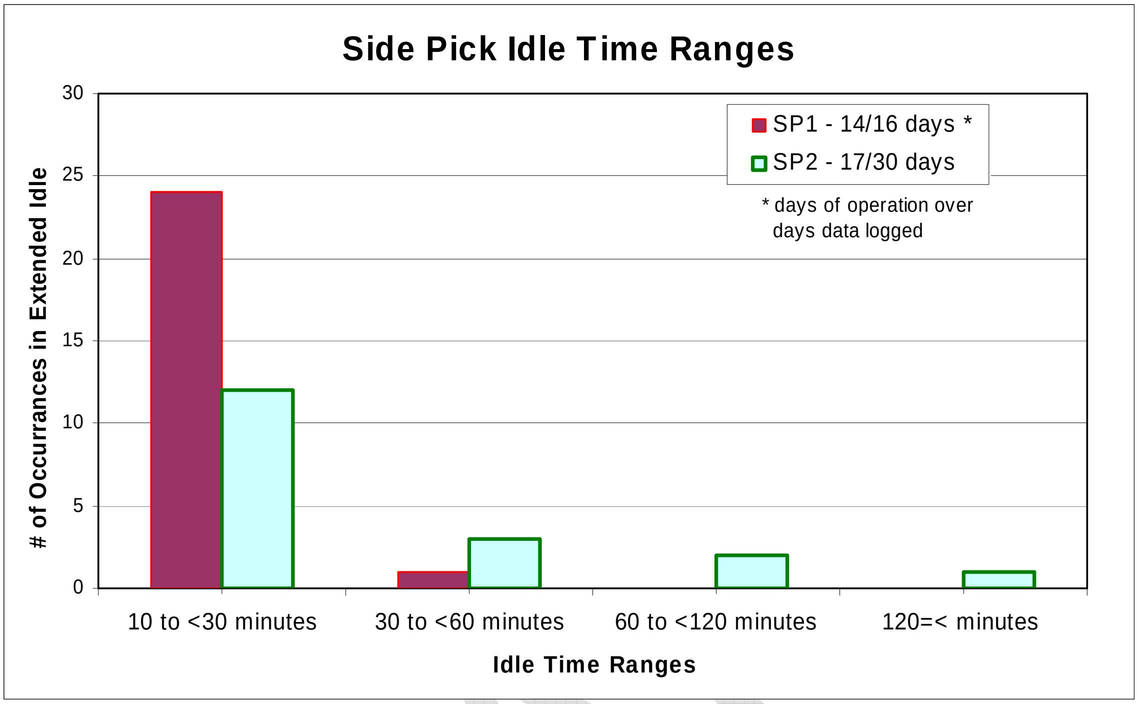


Figure 5: Side Picks Extended Idle Times



The estimated idle times were used to calculate the associated emissions and fuel consumption due to idling and then were projected to annual estimates. The idle emission rates are based on a recent RTG crane emissions test conducted at the Port of Long Beach and these emission rates were used for all three equipment types. The estimated idle engine power, idle emission rates, CO_2 emitted per gallon of diesel burned, and fuel costs used in this report are presented in Table 2 below.

Table 2: Idle Power and Emission Rates and Fuel Amount and Cost Values

Equipment Type	**Engine Power at Idle (hp)**
RTG	9.85
Side Pick	3.30
Top Pick	4.46
Pollutant	**Emission Rates (g/hp-hr)**
PM	1.35
NO_X	15.9
CO_2	2562
GHG and Fuel Cost	**Values**
CO2 g/gallon	9860
Fuel cost $/gallon	$ 2.87 *

*8/17/09 DOE Energy Information Administration

The average results from the three RTG cranes, six top picks, and two side picks under normal operation conditions are presented in Table 3. Detailed information on the individual pieces of equipment can be found in Appendix A.

Table 3: Average CHE Idling Data

	Average per Equipment Type		
Idle times over 10 minutes	**RTG Crane**	**Side Pick**	**Top Pick**
No. of pieces of equipment monitored	3	2	6
Average Idle Time (hh:mm)	0:39	0:25	0:25
Average # of Idles per day operated	5	1.4	1.6
Average Amount of Time Idling per day operated (hh:mm)	3:40	0:33	0:44
Average Amount of Time in Operation per day operated (hh:mm)	9:41	3:54	6:10
Projected # Days Operated per Year	265	246	309
Average Annual Idle (hrs)*	1132	136	254
Average Annual Use (hrs)*	2851	1041	2002
% Idle Time/Operation Time	34%	14%	11%

*Note: Values are averages and may not be consistent with multiplication of other averages.

The RTG cranes appear to idle about a third of their operating time with an average of about 40 minutes per idle. However, maximum idle times for the RTG cranes were recorded up to four hours for a single idle. The total average time spent idling per day for RTG cranes was 3 hours and 40 minutes. The top and side picks idled for less than 15 percent of their operating time with an average of about 25 minutes per idle. The total amount of time idling per day for top picks and side picks was much less than RTG cranes, with an average of about 30 to 45 minutes per day.

The CO_2, PM, and NO_X emissions due to extended idling were then estimated for a typical RTG crane, top pick, and side pick. The average annual emissions and fuel consumption from extended idling for each type of equipment is presented in Table 4.

Table 4: Average Annual Estimated Emissions and Fuel Use Per Equipment Type Due to Extended Idling

	Average per Equipment Type		
Idle times over 10 minutes	**RTG Crane**	**Side Pick**	**Top Pick**
PM lb/year	1.4	0.06	0.14
NO_X lb/year	16.3	0.65	1.7
CO_2 lb/year	2,624	106	267
Diesel gal/year used during idling	121	5	12
Fuel cost/year from idling	$ 347	$ 14	$ 37

The CO_2 emissions associated with extended idling average over a MT per year for a typical RTG crane. Diesel PM emissions were estimated at about

1.4 pound per year (lb/yr) and NO_X emissions were 16.4 lb/yr, based on the average amount of time a single RTG spent idling. RTG cranes have a higher annual use and larger engines than top and side picks so the annual emissions and fuel consumption from idling are considerably higher than for these other equipment types.

If the idling values presented in this analysis are considered representative of the fleet at California ports, then these values can be multiplied by the total number of pieces of equipment in the California port inventory to estimate potential statewide emissions and fuel consumption associated with extended idling. Table 5 shows the statewide inventory of RTG cranes and side and top picks for ports, and presents the annual statewide emissions estimates, fuel use, and fuel cost associated with extended idling of this equipment.

Table 5: Estimated Statewide Emissions and Fuel Cost from Extended Idling of RTGs, Side Picks, and Top Picks at California Ports

	2007 Statewide Emissions by Equipment Type			
Idle times over 10 minutes	**RTG Crane**	**Side Pick**	**Top Pick**	**Total**
Number of pieces of equipment statewide	240	40	420	700
PM lb/year	332	2.2	59	393
NO_X lb/year	3911	26.4	696	4633
CO_2 MT/year	285	2	51	338
Diesel gal/year used during idling	28,992	196	5,082	34,270
Fuel cost/year from idling	$ 83,260	$ 560	$ 15,490	$ 99,310

Based on the current RTG crane port inventory, about 285 MT of CO_2 are emitted statewide and 29,000 gallons of diesel fuel are used at a cost of over $83,000 due to extended RTG crane idling each year. Combined, top and side picks are estimated to emit about 53 MT per year of CO_2 statewide at ports and use about 5,300 gallons of diesel fuel at a cost of $16,000 during extended idling. The three equipment types are estimated to emit approximately 400 pounds of diesel PM and over two tons of NO_X annually due to idling.

Qualification of Analysis

The information in these tables represent a small sample of the California port CHE fleet which were sampled for short time periods in 2005 and 2006. These data are assumed to be representative of typical idling times for this analysis. Additional data are needed to better characterize the fleet. In addition, the data indicate variations from port to port. This difference in operation may show that operation of CHE at various terminals, ports, and railyards could be different and have different idle times. A greater sample size and longer sampling duration are needed to adequately identify any trends or differences between facilities**.**

The choice of using 10 minutes as an excessive idle time may not be the most appropriate cut-off for normal operation. A 10 to 15 minute idle while waiting for the containers may be unavoidable, but there were many idle times well beyond that time noted during the exhaust temperature monitoring. Further information is needed to define what is necessary versus extended idling.

Alternatives to Idling Restrictions

There are options to significantly reduce the fuel consumption and resulting GHG emissions from RTG cranes when idling. One option uses a hybrid system to store the container drop energy and then release it for assisting the container lift. There are two companies with commercial hybrid RTG crane systems available. The other option requires the retrofit of an all electric system so power is only drawn upon when needed and does not require leaving the diesel generator running when not needed.

Conclusion

RTG cranes appear to be operated in a manner that allows extended idling periods that creates preventable GHG emissions and uses fuel needlessly. Each year a single RTG crane is estimated to emit over one MT of CO_2 due to extended idling while operating in the ports in California, creating about 285 MT per year of CO_2 emissions statewide. A typical idling RTG crane consumes on average about 120 gallons of diesel per year, costing an operator about $347 in fuel costs.

Data indicates that the top and side picks idle much less frequently for extended times and do not produce nearly the amount of CO_2 emissions as the RTG cranes. A typical top pick produces about 270 pounds of CO_2 each year and consumes about 12 gallons of diesel fuel during extended idles. Side picks appeared to have the least amount of extended idles, emitting only about 110 pounds of CO_2 emissions and using about 5 gallons of diesel fuel. Statewide, top and side picks at ports may create an additional 53 MT of CO_2 emissions due to extended idling each year.

As mentioned above, additional data are needed to better characterize the fleet and understand how emissions may be reduced. The frequency and extremely long idle times associated with CHE equipment, especially RTG cranes, may be reduced with changes in operational procedures. Alternatives also exist to reduce idling times. These options should also be explored to determine the feasibility of reducing GHG emissions from CHE idling.

Appendix A: Individual Equipment Data

Port of Oakland CHE Idling Information

	Oakland		
Idle times over 10 minutes	**RTG 3**	**Side Pick 2**	**Top Pick 6**
Average Length of Idle (hh:mm) =	0:26	0:36	0:13
Maximum Length of Idle (hh:mm) =	2:23	2:04	0:13
# of Long Idles =	80	18	1
Total Amount of Time in Long Idles (hh:mm) =	34:35	10:42	0:13
Total Amount of Time in Operation (hh:mm) =	131:05	63:11	13:32
Days of Operation	20	17	11
Data Log Over # of Days	30	30	20
% Idle Time/Operation Time	26%	17%	2%
Projected Annual Use (hrs)	1595	767	247
PM g/year	233	24	1.0
NO_X g/year	2,745	285	12
CO_2 g/year	442,388	45,881	1,899
Diesel gal/year	45	5	0.2
Fuel cost/year	$ 157	$ 16	$ 0.7

Ports of Los Angeles and Long Beach CHE Idling Information

	Ports of Los Angeles and Long Beach							
Idle times over 10 minutes	**RTG 2**	**RTG 1**	**Top Pick 1**	**Top Pick 2**	**Top Pick 3**	**Top Pick 4**	**Top Pick 5**	**Side Pick 1**
Average length of idle (hh:mm) =	0:35	0:57	0:24	0:20	0:37	0:30	0:28	0:15
Maximum length of idle (hh:mm) =	1:33	4:15	1:09	0:41	2:30	2:10	1:15	0:45
# of long idles =	40	113	16	18	16	38	33	25
Total amount of time in long idles (hh:mm) =	23:27	107:04	6:30	6:07	9:45	19:13	15:26	6:18
Total amount of time in Operation (hh:mm) =	80:50	224:11	76:26	94:30	48:26	111:34	136:19	57:37
Days of operation	10	15	16	13	6	16	16	14
Data Log over # of days	16	16	16	16	8	16	16	16
% Idle Time/Operation Time	29%	48%	9%	6%	20%	17%	11%	11%
Projected Annual Use (hrs)	1844	5114	1744	2156	2210	2545	3110	1314
PM g/year	296	1,353	37	35	111	110	88	27
NO_X g/year	3,491	15,936	438	412	1,313	1,294	1,039	314
CO_2 g/year	562,606	2,568,272	70,530	66,461	211,589	208,538	167,508	50,612
Diesel gal/year	57	260	7	7	20	21	17	5
Fuel cost/year	$200	$912	$25	$24	$71	$74	$59	$18